

TABLE OF CONTENTS

1	INTRODUCTION.....	1
2	LITERATURE REVIEW.....	6
2.1	Biological nitrogen fixation.....	6
2.1.1	Biological nitrogen fixation in agroforestry systems	7
2.1.2	<i>Gliricidia</i> (<i>Gliricidia sepium</i> [Jacq.] Walp.).....	8
2.2	Methods for quantifying biological nitrogen fixation	10
2.2.1	Nitrogen-15 enrichment method (^{15}NEM)	11
2.2.2	Nitrogen-15 natural abundance method ($^{15}\text{NNAM}$).....	14
2.2.3	Comparison of ^{15}NEM and $^{15}\text{NNAM}$	18
3	MATERIALS AND METHODS	20
3.1	Study area	20
3.1.1	Site description	22
3.1.2	Soil.....	24
3.1.3	Climate.....	26
3.2	Experimental design	27
3.2.1	Nitrogen-15 enrichment method.....	27
3.2.2	Nitrogen-15 natural abundance method	30
3.2.3	Infection potential.....	33
3.2.4	Aboveground biomass	33
3.3	Sampling methods and analyses	34
3.3.1	Plant samples	34
3.3.2	Soil samples.....	35
3.4	Statistical analysis.....	36
4	RESULTS AND DISCUSSION	38
4.1	Nitrogen-15 enrichment method.....	38
4.1.1	Atom% ^{15}N excess and % N_{tot} in soil	38
4.1.2	Atom% ^{15}N excess and % N_{tot} in plants	43

4.1.3	Proportion of N derived from atmospheric N ₂ (%Ndfa) of Gliricidia estimated with ¹⁵ NEM	46
4.2	Nitrogen-15 natural abundance method	50
4.2.1	The δ ¹⁵ N value and %N _{tot} in soil	50
4.2.2	The δ ¹⁵ N value and %N _{tot} in plants	55
4.2.3	Nitrogen-15 discrimination (<i>B</i> -value)	60
4.2.4	Proportion of N derived from atmospheric N ₂ (%Ndfa) of Gliricidia estimated with ¹⁵ NNAM.....	62
4.3	Comparison of ¹⁵ NEM and ¹⁵ NNAM	66
4.4	Infection potential.....	70
4.5	Leaf litterfall and pruning of Gliricidia	71
4.6	Total aboveground biomass and N content of Gliricidia.....	73
4.7	Nitrogen balance in cacao agroforestry system.....	74
5	GENERAL DISCUSSION AND CONCLUSIONS.....	77
5.1	Quantifying %Ndfa of Gliricidia.....	77
5.1.1	Nitrogen-15 enrichment method.....	77
5.1.2	Nitrogen-15 natural abundance method	80
5.1.3	Comparison of ¹⁵ NEM and ¹⁵ NNAM	83
5.2	Role of BNF in cacao agroforestry system in Central Sulawesi	86
6	CONCLUSIONS AND RESEARCH NEEDS	88
6.1	Conclusions	88
6.2	Research needs	89
7	REFERENCES.....	90
8	APPENDICES.....	100

ACKNOWLEDGEMENTS